

# Structural Materials for Fusion Reactors

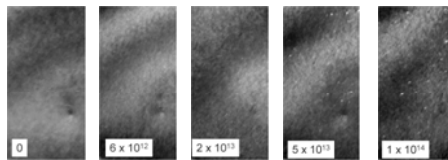
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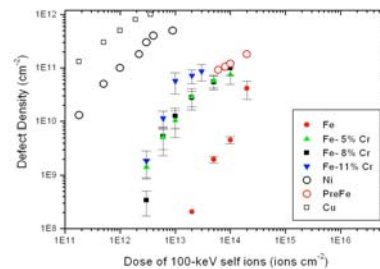
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Structural components of commercial fusion power plants will be exposed to high fluxes of 14 MeV fusion neutrons. The most promising candidate materials for such applications are low-activation ferritic/martensitic steels, typically containing about 9% Cr and smaller quantities of W, V and Ta. These steels show a high resistance to void swelling. However they exhibit low-temperature, irradiation produced hardening which may make their use problematic at temperatures below 400°C. The hardening is believed to be due to the accumulation of radiation damage.

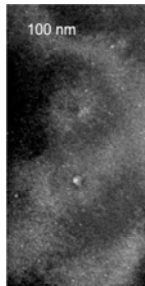
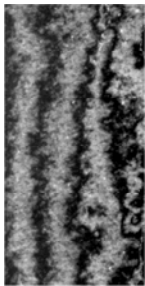
This program concerns experimental studies of the development of radiation damage in the generic class of ferritic materials based on Fe-Cr, and of studies of the efficacy of damage clusters in impeding the motion of dislocations. Model Fe-Cr alloys are included for two reasons. First, in these relatively simple materials it should be easier to characterize damage and discern fundamental damage mechanisms. Second it is known that the value of the ductile to brittle transition temperature (DBTT) as well as the change in the DBTT on irradiation ( $\Delta$ DBTT) both depend on the Cr content. Both the DBTT and  $\Delta$ DBTT are a minimum at Cr content of about 9%. However, the reason for this is not understood, and gaining an understanding is one of the main objectives of the whole program.



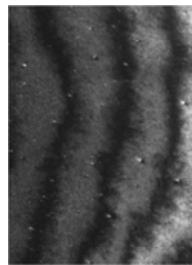
In situ ion irradiation (100 keV Fe+) of Fe+8%Cr alloy. White dot features are 2-4nm dislocation loops.



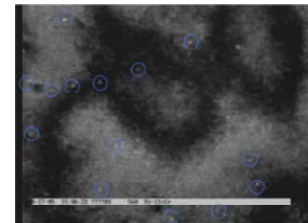
Order of magnitude greater dislocation loop formation in Cr alloys than in pure Fe.



Fe at  $2 \times 10^{14}$  ions/cm<sup>2</sup> Fe-11%Cr at  $3 \times 10^{13}$  ions/cm<sup>2</sup>  
Comparable defect densities at greatly different doses.



Black/white defect contrast indicates vacancy nature.



Video rate data showed some dislocation loop formation over 0.05-0.3sec. by unknown mechanism.

**Conclusion and Significance:** Formation of dislocation loop defects under irradiation strongly enhanced by Cr additions to Fe. Relationship to decrease in hardening by Cr additions suggested, but defect state before loop formation is critical state.

**Future work:** Similar in situ TEM experiments at elevated temperatures planned to better understand effects of Cr additions to defect formation processes. Correlations with in situ TEM straining experiments proposed to understand hardening result. Diffuse electron scattering experiments to probe defect state before formation of dislocation loops.

*This work is from last 5 months, but has already been presented at European Fusion Materials Conference, Dec. 2005.*